CROOKED LAKE

WATERSHEDS OF THE CARPENTER AND PALFREYMAN DITCHES

FEASIBILITY STUDY

T BY 2000

LAKE ENHANCEMENT PROGRAM

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EXECUTIVE SUMMARY

The quality of the water of Crooked Lake is influenced in part, by the inflow from the Carpenter and Palfreyman Ditches. The two ditches enter the lake on the east end of the lower basin, and serve a total of approximately 3,100 acres lying between the lake and the city of Angola. The watershed is composed of five distinct land uses;

1 - the northwest quadrant and part of the southwest quadrant of the city which includes residential, commercial, and industrial uses.
2 - a portions of the Tri-State University campus with typical diverse land uses.
3 - significant commercial development along the arteries between the city and the lake region.
4 - agricultural and undeveloped land.
5 - a significant rural residential area.

Although Angola and Steuben County are in a significant growth mode, the major portions of the Carpenter and Palfreyman watersheds exhibit a relatively stable land use pattern. A small increase in residential development is expected along with some commercial expansion in the area between the city and the lake.

The study verified two problems associated with the water quality. The phosphorus concentrations obtained during sampling of the Carpenter and Palfreyman Ditches have shown an increase of 2.4 and 4.5 times respectively over the past ten years. This may indicate a trend of increasing phosphorus loading to the lake through these ditch inflows. The lake itself has not exhibited the same change due largely to the Regional Waste District, solving some of the severe septic system contributions.

Excessive sedimentation, a long standing problem for the east end of the lake, remains a significant problem. The sediment load is the result of a number of conditions:

1 - presence of highly erodible soils,
2 - lack of adequate vegetable cover in some of the underdeveloped areas,
3 - the absence of appropriate soil management techniques, and
4 - increased flow rates due to the increase of paved areas.

Recommendations

Correction of the problems is feasible, and centers on control of nutrients and sediment within the watershed.

A. The major steps can be readily initiated by local officials, and include:

   1 - construction of sedimentation basins near the mouth of, and along, both ditches.

   2 - upgrading of the storm sewer discharges to meet NPDES requirements, and

   3 - retention and active protection of the existing wetlands within the two watersheds.

B. Educational services, in respect to the impact of development on the downstream problems, could be effectively provided by cooperation between the Steuben County Soil and Water Conservation District and the Steuben County Lakes Council.

C. The installation of erosion and sediment control practices during the additional development within the watershed is critical. The enactment of an erosion control ordinance by both the City of Angola and Steuben County would greatly enhance this progress.

D. Encourage the increased use of Best Management Practices within the agricultural portion of the watershed to control sheet, rill, gully erosion, and the proper management of animal waste and commercial fertilizer.

I. PERSPECTIVE

Steuben County, a resort area of northeastern Indiana, contains approximately 100 lakes varying in size from a few acres to over 1000 acres. The lakes and associated activities have a significant economic impact on the region. County population during the winter months is between 20 and 30 thousand; expanding to an estimated 200,000 during the summer. Steuben County is reportedly one of the fastest growing counties in the state of Indiana.

Most of the county watershed drains into the West through Pigeon Creek and Fawn River to Pigeon River and eventually to the St. Joseph River and Lake Michigan. The northeast corner of the county drains to the south to the Maumee basin and Lake Erie.

The major lakes in the area are virtually saturated with residential development, reflecting and expansion in seasonal and full time lake population that has taken place over the past 30 years. Industrial expansion has been actively and successfully pursued in recent years. These expansions together with the natural follow-on commercial development are beginning to stretch the county´s infra-structure. During the growth of the regions, however, the effect on the lakes and streams was often disregarded in the planning and approval processes with respect to expansion and development. The two largest county lakes, James and Crooked, are two examples where unnecessary harmful affects have been allowed to continue, and justify the need for study and corrective action.

II. OBJECTIVES

Crooked Lake is the second largest body of water in the county, comprising approximately 830 acres. The quality of the lake is affected by three primary factors:

1 - lake shoreline residential and commercial development,

2 - inflow through drainage ditches serving a portion of the surrounding watershed, and

3 - the county park and campground.

Two major inflow streams to Crooked Lake exist; the Carpenter and Palfreyman drains, shown in Figure I. The Carpenter drain serves approximately 1800 acres and the Palfreyman 1200 acres. Past observations, water sampling, and measurements have indicated severe nutrient and sediment loads in the entering streams to the lake. Figures II through VIII, taken in June 1988, clearly indicate the severity of the sediment problem at the mouth of both drains. The two streams enter the lake less then one-half mile apart, on either side of the county park and campground.

The nutrient levels are the result of several land uses while the sediment problems are largely the result of improper management of the topsoil and control of flow rates. Figure IX depicts a typical lack of erosion control during construction at a site along the Palfreyman Ditch.

The objectives of the study are the verification of the magnitude of the problems, evaluation of the watershed land use patterns, identification of the major sources of the problems, and determination of the feasibility of providing corrective action.

III. SAMPLING AND SURVEY METHODS

The watershed land use was determined from the 1987 ASCS aerial photographs, 1989 cropland acreages, and field observation. The Steuben County Soil Survey was used to identify soils as highly erodible. These were color coded on the soil maps and acreages determined.

Nutrient and sediment samples were taken by grab methods during the summer of 1988, and are presented in Tables I through IV. The samples were split and analyzed for phosphorus by persulfate digestion, followed by the stannous chloride colormetric method given in Standard Methods. Sediment amounts were determined by filtration through a 47 micron millipore membrane and weighed.

Storm hydrographs at two stations were determined from flow measurements using a temporary wooden weir. Measured date was extrapolated backward in time to the storm onset to obtain an estimate of the total flow quantity.

IV. WATERSHED LAND USE

The watersheds and ditch courses of the Palfreyman and Carpenter drains are shown in Figure I. The watersheds lie adjacent to the Croxton watershed which serves Lake James to the northeast. The acreage served by the streams is comprised of a variety of land uses, each representing a significant portions of the total. As opposed to the dominant agricultural land use in the Croxton watershed, residential, commercial, and agriculture all exhibit approximately the same acreage of use in these watersheds.

The distribution is as follows;

Use		Acreage	Percent
Carpenter			
Industrial		120	6
Commercial		240	13
Residential		550	30
Agricultural		520	28
Cropland	470		
CRP	50		
Woods		68	4
Wetlands		358	19
Total		1,856	
Palfreyman			
Industrial		110	9
Commercial		320	26
Residential		350	29
Agricultural		260	21
Cropland	232		
CRP	28		
Woods		140	11
Wetlands		50	4
Total		1,230	

The wetland total acreage in the Carpenter watershed includes significant acreage associated with the three small lakes in the Center Lake chain. Figures X through XIV, depict the distribution and location of the various land uses throughout the watershed.

The above acreage represents the situations in early 1989. The land use pattern in both watersheds appears to be relatively stable for the near future. Small increases in residential development will occur in small pockets in the area. A slight increase in commercial use of the land along CR 200 W in both watersheds is expected. This study has already caused the county to take a close look at a major commercial development along SR 127, adjacent to the Palfreyman drain.

V. WATERSHED CHARACTERISTICS

The Carpenter and Palfreyman drains serve the major portion of the northwest and southwest quadrants of the city of Angola, and the flows, therefore, carry a heavy street runoff with the corresponding short transportation times to the drains and normal contaminants. The problems associated with these components is partially handled in the Carpenter watershed by the wetlands and enclosed waters associated with the Center Lake chain.

The primary water treatment plant serving the City of Angola is located near the head of the Carpenter ditch. Over the years, discharges associated with this facility have caused problems in the flow entering Little Center Lake. Recent improvements have tended to alleviate much of this problem.

The elevation of Crooked Lake is approximately 23 feet higher than that of Lake James, and therefore the slopes of the Carpenter and Palfreyman ditches are much smaller that of the Croxton ditch. Consequently, peak flow rates are lower, hydrographs are flatter, and the ditches near the lakes contain a significant amount of water during most of the year. In contrast, most of the Croxton ditch is dry soon after the end of the storm event.

Although not directly associated with the inflow streams, extensive activities and runoff characteristics of the County Park, campground, and 4-H Park, seem to indicate a significant impact on the Crooked Lake water quality.

Rainfall The Angola rainfall records for a period of thirteen months are presented in Appendix A. The middle five months were unusually dry, and the ditch flows correspondingly low. The weather station is located approximately two miles east of the beginning of the ditches.

Soils Pertinent soil type information from the 1981 county survey is presented in Figure XV. The major direct impact of soil type on the situation under study is the susceptibility to erosion under the influence of wind and water. Some soil types are more prone to erosion because of their physical characteristics, steepness and length of slope, and direct contact with wind and water. The presence of residue and living vegetation can greatly reduce erosion of these potentially erosive soils.

In the two watersheds under study, over 90 percent of the soils can be considered as causing potential problems. Those classified as such soils, have an average to high value of erosion factor K, and are in the wind erodible group 1, 2 or 3. Figure XV, indicates those areas which are not classified as severe, and are primarily the regions surrounding the Center Lakes.

VI. QUANTITATIVE ASSESSMENT

A. Flow rates

The use of computer models, particularly TR 55 and TR 20, was considered for flow rate comparison and model verification. Due to the unique characteristics of the watershed and, to some extent the drought conditions of 1988, it was felt that the effort would be unproductive. Much of the watershed is extremely chopped up with respect to terrain and slopes; and contains a large number of laterals and small interceptor tiles. In addition, the Center Lake chain and associated wetlands provide a damping effect on the flows in the Carpenter ditch.

Due to the drought conditions, measures flow rates in 1988 will, for the most part, represent minimum conditions.

Typical measured flow rate data is illustrated in Figure XVI and XVII, corresponding to storm events of August 5, and September 4, 1988, respectively. The maximum flow rate observed is in line with the mean rate of 2.47 cfs indicated in the 1976 EPA Working Paper 325 on the eutrophication survey of Crooked Lake.

In order to obtain an estimate of the integrated total flow, and extrapolation of the hydrograph is made to zero time. A base flow rate of 0.4 cfs was taken. In spite of the inherent uncertainties and inaccuracies, the result should be a reasonable estimate of the total flow information that will assist in evaluating potential storage and detention areas.

B. NUTRIENT AND SEDIMENT LOAD

1. Ditches The Carpenter Ditch inflow data is represented in Tables 1 and 2. The Palfreyman Ditch inflow is present in Tables 3 and 4. Figures 18 and 19 compare the nutrient levels for data from the monitoring programs of the Steuben County Health Department and the Steuben County Lakes Council of previous years. In 1973 (11 samples), 1974 (16 samples), 1975 (8 samples), 1976 (11 samples), and in 1977 (7 samples) were taken at the culvert at the 4-H Park entrance, the mouth of the Carpenter Ditch. In 1987, (5 samples) and 1988 (4 samples) were collected. A similar sampling schedule was completed on the Palfreyman Ditch. In 1973, (7 samples), 1974 (19 samples), 1975 (8 samples), 1976 (11 samples), and 1977 (7 samples) were taken by the Steuben County Health Department. The Steuben County Lake Council funded the 1987 and 1988 sampling which consisted of 5 and 7 samples respectively. These samples were taken at 200 West, the mouth of the Palfreyman Ditch.

The average total phosphorus concentration for the Carpenter Ditch inflow was 0.125 mg/l in the 1970´s and 0.30 mg/l in the 1980´s, an increase of 2.4 times for this inflow. The Palfreyman Ditch had an average total phosphorus concentration of 0.052 mg/l and 0.235 mg/l for the same time periods, a 4.5 times increase for the Palfreyman Ditch is evident for the same ten year time period. The magnitude of this increase may overstate the current nutrient loading problems compared to the 1970´s, because it is not known if all the 1970 data was related to storm events as in the 1988 data.

The EPA sampling of 1973 indicated that 66 percent of the nutrient loading for Crooked Lake came from tributaries. This same study determined that 71 percent of the phosphorus input form the tributaries came from the Carpenter Ditch, while 20 percent came from the Palfreyman Ditch. Based on the sampling data of this study it appears that there has been a shift in the relative magnitude of nutrient input into Crooked Lake from the Palfreyman Ditch. The exact amount of this shift can not be determined without more complete flow rates.

The Skinner Lake Study indicates that 90 percent of the phosphorus entering a typical northeastern Indiana lake is attached to sediment particles. According to the EPA´s phosphorus budget for Crooked Lake, 86 percent of the phosphorus is coming from nonpoint sources. Therefore the amount indicated on Tables 2 and 4 and Figures IV, V, VI, and VII constitute the watershed management challenge if the water quality of Crooked Lake is to be maintained or improved.

2. Crooked Lake The Indiana State Board of Health developed the Lake Eutrophication Index which is based on eleven parameters. In the early 1970's, the Eutrophication Index for Crooked Lake was 23. In 1986, this index was updated by the Indiana Department of Environmental Management in it's 305(b) report to a value of 17. The Eutrophication Index ranges from 0 to 75 with zero being the best water quality condition and 75 the worst. Although Crooked Lake has improved six index points over this 14 year period, this does not indicate a shift in the eutrophic condition because of the inherent variability of the eutrophication index. The same reports indicate an improvement of total phosphorus from 0.05 mg/l to 0.03 mg/l within the lake.

The 1973 sampling and modeling of phosphorus loading for Crooked Lake by the EPA estimated that 6.5 percent of the total phosphorus load was coming form shoreline septic systems. In 1978, a leachate sampling, done for the Environmental Impact Study for the Steuben County Lake Regional Waste District, indicated 22 erupting plumes from septic systems long the shoreline of Crooked Lake. These septic systems, along with many other systems, in the areas of similar elevation and soil types were corrected with the construction of several cluster systems away from the shoreline of the lake.

During these years, the Crooked Lake Cottage Owners Association has pursued and extensive weed control program for the lake. Approximately 16,000 dollars a year is spent on two herbicide applications each year. Each year 360 association members each contribute 28 dollars for weed control while the Steuben County Commissioners contribute 5,000 dollars. This county contribution is in conjunction with the Crooked Lake Campgrounds, owned and operated by the county.

Over the same time period several secchi disk reading have been take as well as lake total phosphorus concentrations by several governmental agencies and universities.

Year		Readings in feet	Total-P mg/l
1972	ISBH	8	0.05
1973	EPA	7.8 9.3	0.017, 0.03, 0.04
1977	Purdue	6.5 8.75	0.026, 0.018
1978	Purdue	7.8 9.4	0.026, 0.026
1986	IDEM	6	0.03
1988	Tri-State	8.2 9.2	0.03
1989	Tri-State	8.0 9.5	0.03

Some of these readings are averages of more than one station and other are averages of different times of the year. As you can see from the above readings, there has been no clear change in water clarity or phosphorus concentration over the last 16 years.

VII. CONCLUSIONS

In terms of the four programs objectives as stated in Section II.

A. Magnitude of Problem

The nutrient load in the Carpenter and Palfreyman Ditches has increased 2.4 and 4.5 times respectively over the past ten years.

Although reference sediment data does not exist prior to 1988, it has been apparent that changes of residential, commercial, and industrial development in the Crooked Lake watershed have amplified the erosion problems. This has been compensated somewhat by diversions of nutrients and other chemicals into the Angola Sanitary Sewer system, instead of the storm drains that run into the Center Lake chain and therefore the Carpenter Ditch. Also, the completion of the cluster systems to upgrade the lake residential septic systems has helped reduce the nutrient input into Crooked Lake.

B. Watershed Land Use

Many commercial developments such as Angola Square Plaza, Peachtree Plaza, and others have changed the character of the watershed. It places new problems of increased hydraulic loading, road salt, oils from parking lots, and wetland loss which all contribute to the cumulative effects on Crooked Lake.

C. Problems Sources

Nutrients All areas of the watershed contribute to the nutrient load. The major sources are associated with activities that allow erosion, such as exposed soil during both farming and construction activities.

Sediments The presence of such a high percentage of highly erodible soils in the watershed makes it imperative that vegetable cover, proper residue management, proper soil management during construction, and ditch bank design and maintenance be utilized to the fullest.

D. Feasibility of Correction

1. Sediment basins should be constructed near the

mouth of each ditch. These basins must be maintained on a regular basis. The use of constructed wetlands does not appear to be feasible in this region of the watershed. Other wetlands in the watershed should be maintained for their filtering functions, particularly in the region of the Center Lake chain.

2. Land Use Management

Agriculture Several types of reduced tillage and associated residue management, the use of appropriate vegetative cover on the highly erodible soils, filter strips, grass waterways, and terraces are possible site specific solutions to reducing erosion on agricultural land.

The Classified Filter Strips Act provide incentives to landowners who establish vegetative filter strips adjacent to ditches, creeks, rivers, wetlands, or lakes. By establishing vegetated filter strips, a landowner can have those parcels assessed at only $1.00 per acre for general taxation purposes. To qualify, the strips must be between 20 and 75 feet wide and meet certain other requirements. The county surveyor, in cooperation with the county extension service and the county Soil and Water Conservation District will provide advice and technical assistance to the landowner for the establishment and maintenance of filter strips.

Also, proper nutrients management of both commercial fertilizers and animal wastes are critical to reducing lake input. The Steuben County Soil and Water Conservation District should be involved in the selection the most appropriate BMP's for each situation.

Non-agriculture Angola should upgrade their storm sewer discharges to meet new NPDES permit requirements. Storm water retention, erosion control during construction, proper design of ditch inflow structures, and stabilization of existing ditch conditions will all contribute to the improved water quality in the Crooked Lake watershed. The adoption of an Erosion Control Ordinance and education of all sectors involved could enhance the correction of a growing problem. Again, the Steuben County Soil and Water Conservation District could be the ideal lead agency.

VIII. Recommendations

The following are in order of their priority:

A. The following items can be initiated by existing county agencies.

1. The Drainage Board should design and construct sediment basins near the mouth of both the Carpenter and Palfreyman Ditches.

2. The City of Angola should upgrade their storm sewer discharges to meet NPDES permit requirements.

3. Storm water retention should be incorporated into all residential, commercial, and industrial development plans.

4. Retain the current wetlands within the Crooked Lake watershed.

B. Implement an Erosion Control Ordinance in the planning ordinances of Steuben County and the city of Angola.

C. Provide an educational service to city and county agencies with respect to the impact of development on the downstream problems. Such educational services could be effectively provided in cooperation between the Steuben County Soil and Water Conservation District and the Steuben County Lakes Council.

D. Encourage the agricultural sector of the watershed to apply the following Best Management Practices (BMP´s) where needed:

1. Nutrient management of both commercial fertilizers and animal wastes.

2. Reduced tillage with proper residue management.

3. Filter strips along both the Carpenter and Palfreyman Ditches in both agricultural and commercial areas.

4. Other site specific BMP´s as recommended by the Steuben County Soil and Water Conservation District.

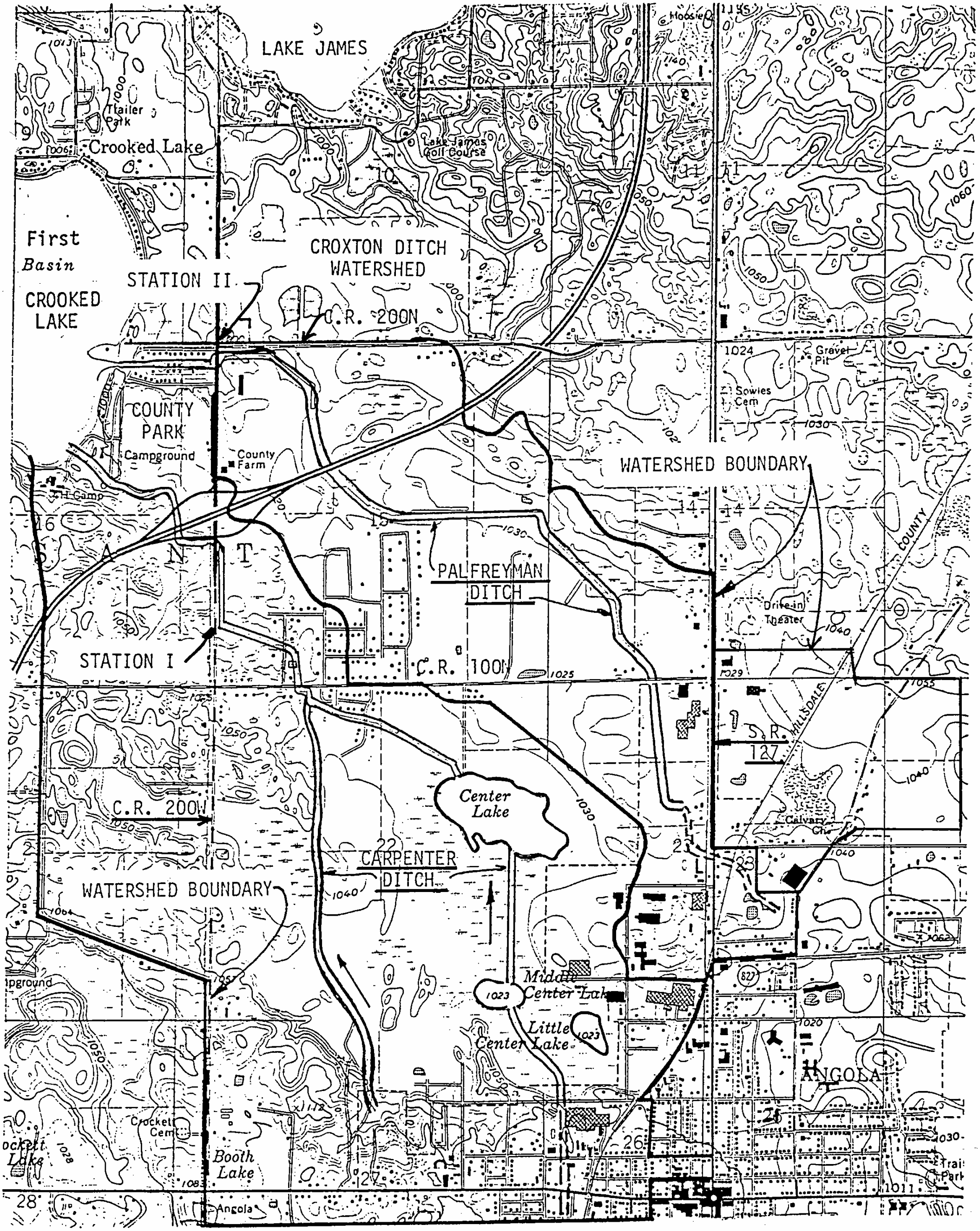


Figure I. The Carpenter and Palfreyman Ditches

Ditch Course ——— Watershed Boundary

Scale: 1/ 24,000

Figure II. Palfreyman Ditch entering Crooked Lake; Normal Conditions.

Figure III. Carpenter Ditch entering Crooked Lake; Normal Conditions.

Figure IV. Palfreyman Ditch entering Crooked Lake; Storm Conditions.

Figure V. Carpenter Ditch entering Crooked Lake; Storm Conditions.

Figure VI. Channels upstream of the mouth of Palfreyman ditch; Storm Conditions.

Figure VII. Steuben County Campground between Carpenter and Palfreyman Ditches.

Figure VIII. Typical bar formation at exit of Palfreyman culvert.

Figure IX. Site preparation near Palfreyman Ditch; Erosion control ordinances needed.

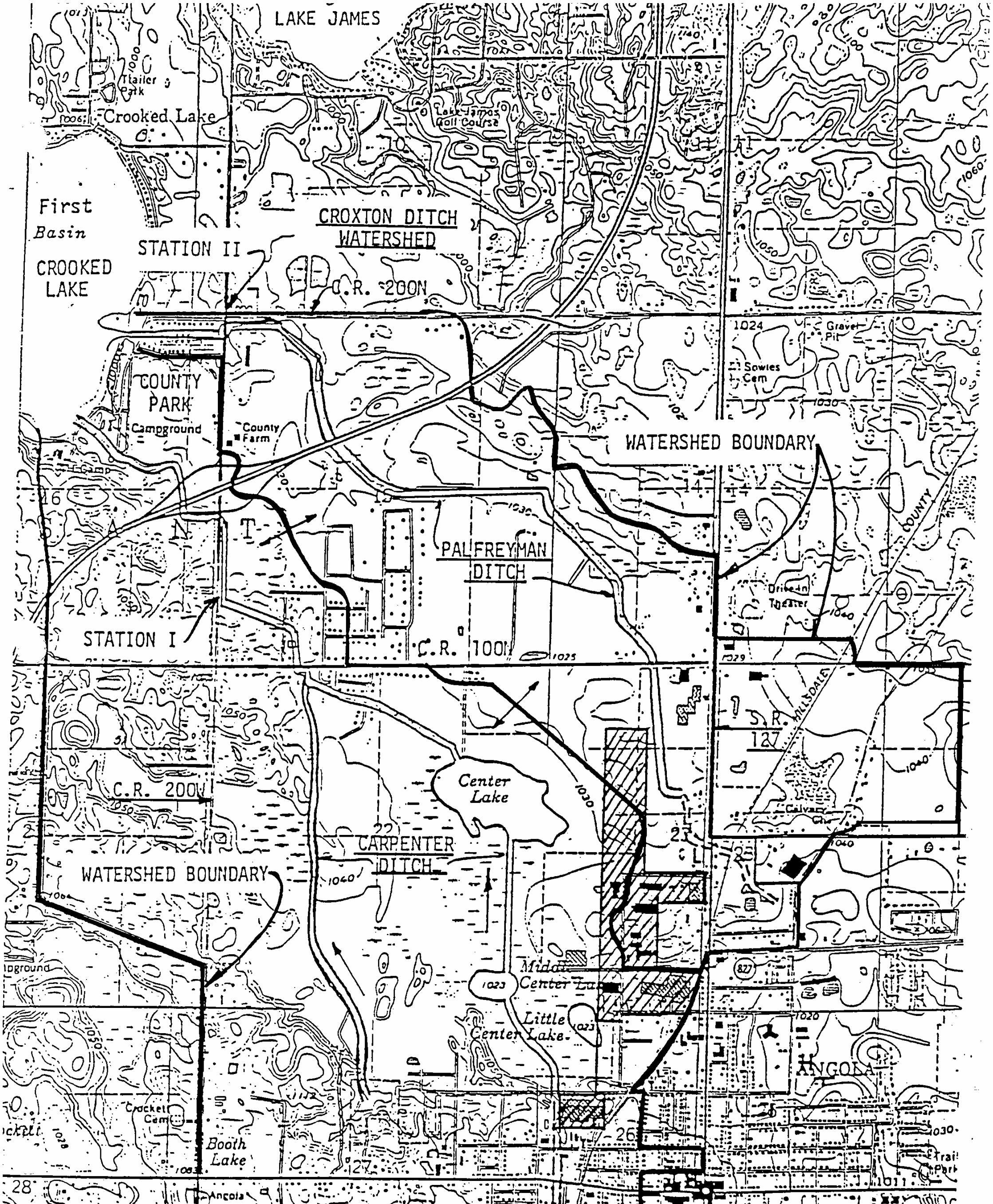


Figure X. The Carpenter and Palfreyman Ditches; Land Use
Ditch Course —— Watershed Boundary

Industrial

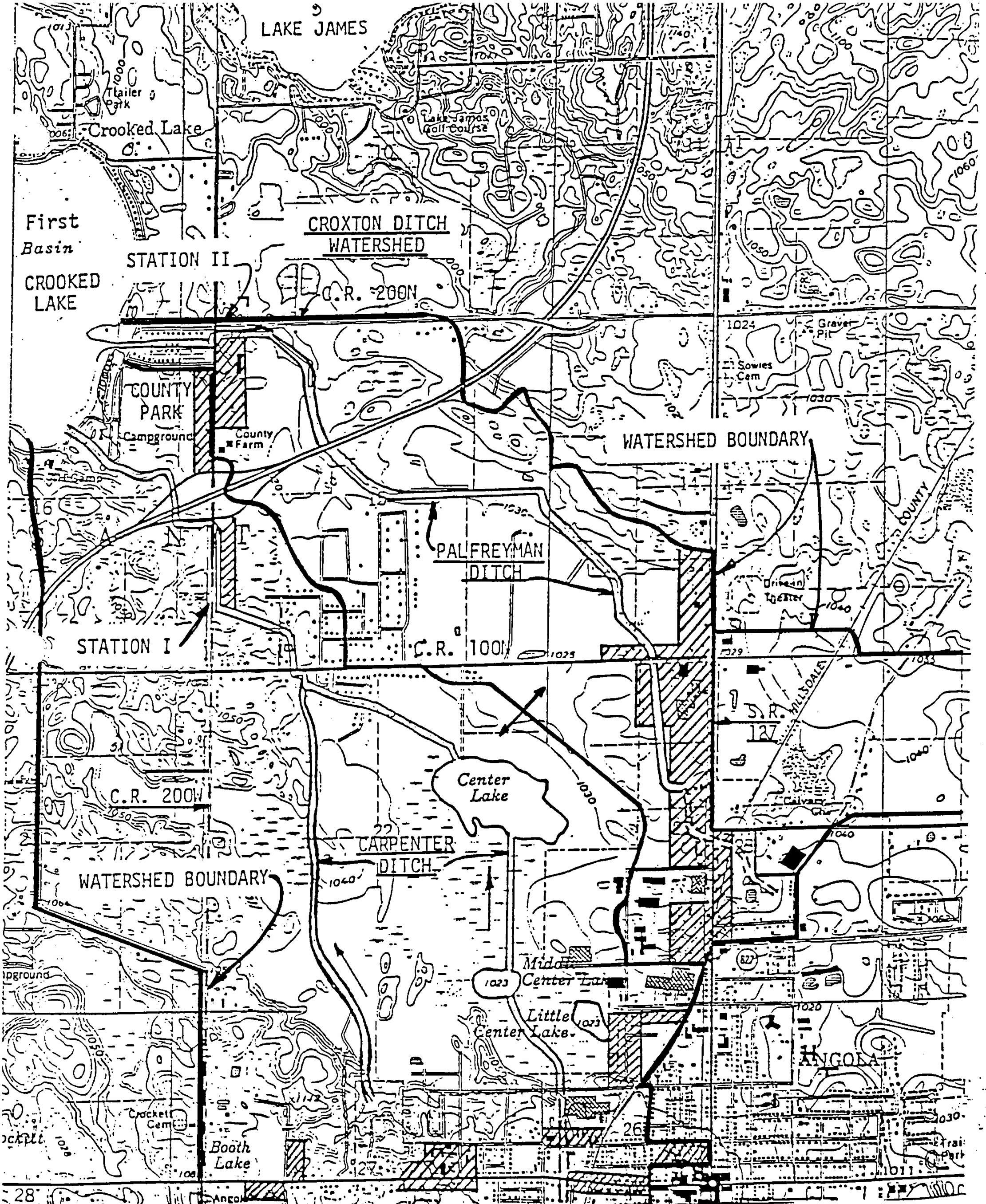


Figure XI. The Carpenter and Palfreyman Ditches; Land Use

Commercial — Ditch Course — Watershed Boundary

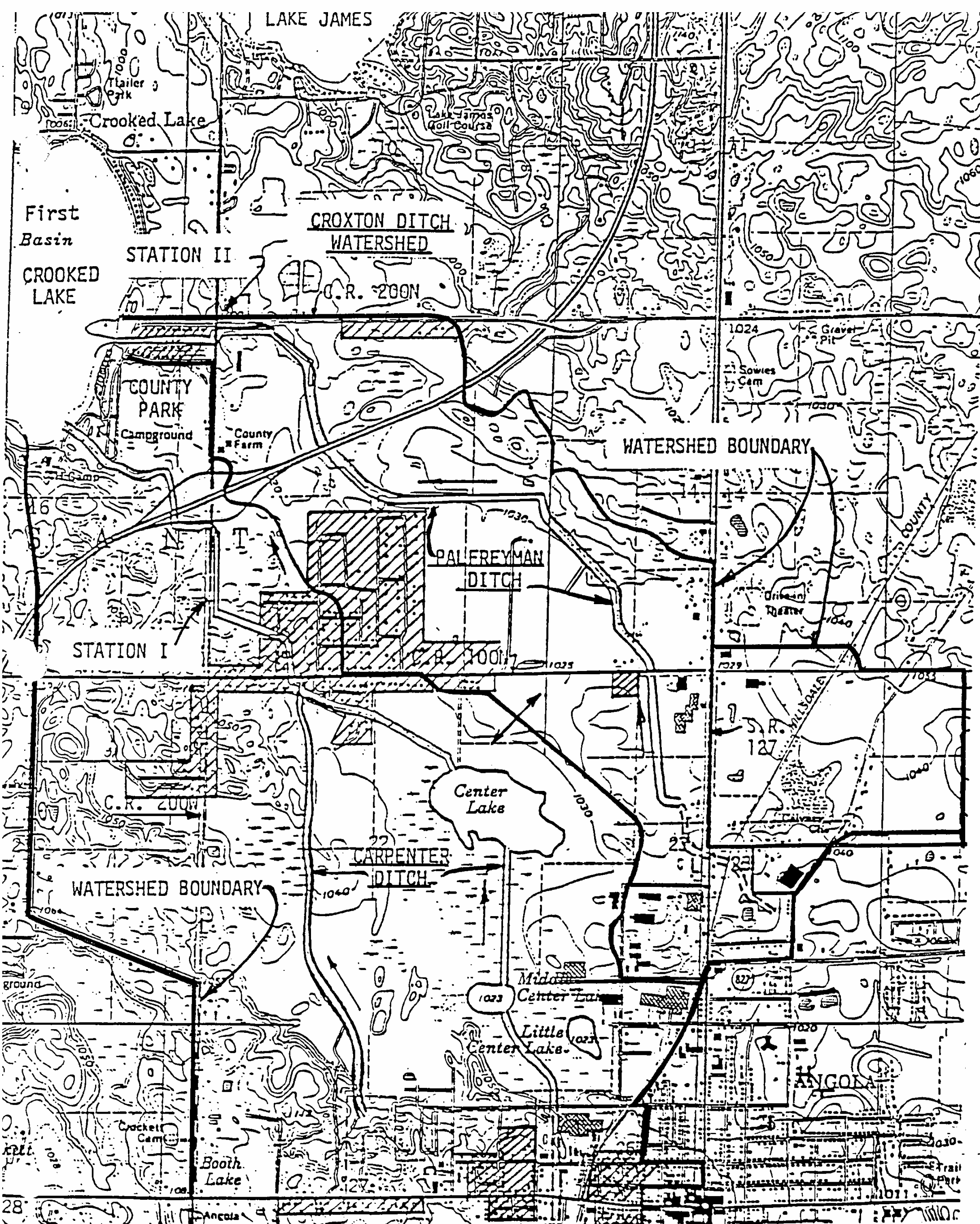


Figure XII. The Carpenter and Palfreyman Ditches; Land Use

Residential — Ditch Course — Watershed Boundary

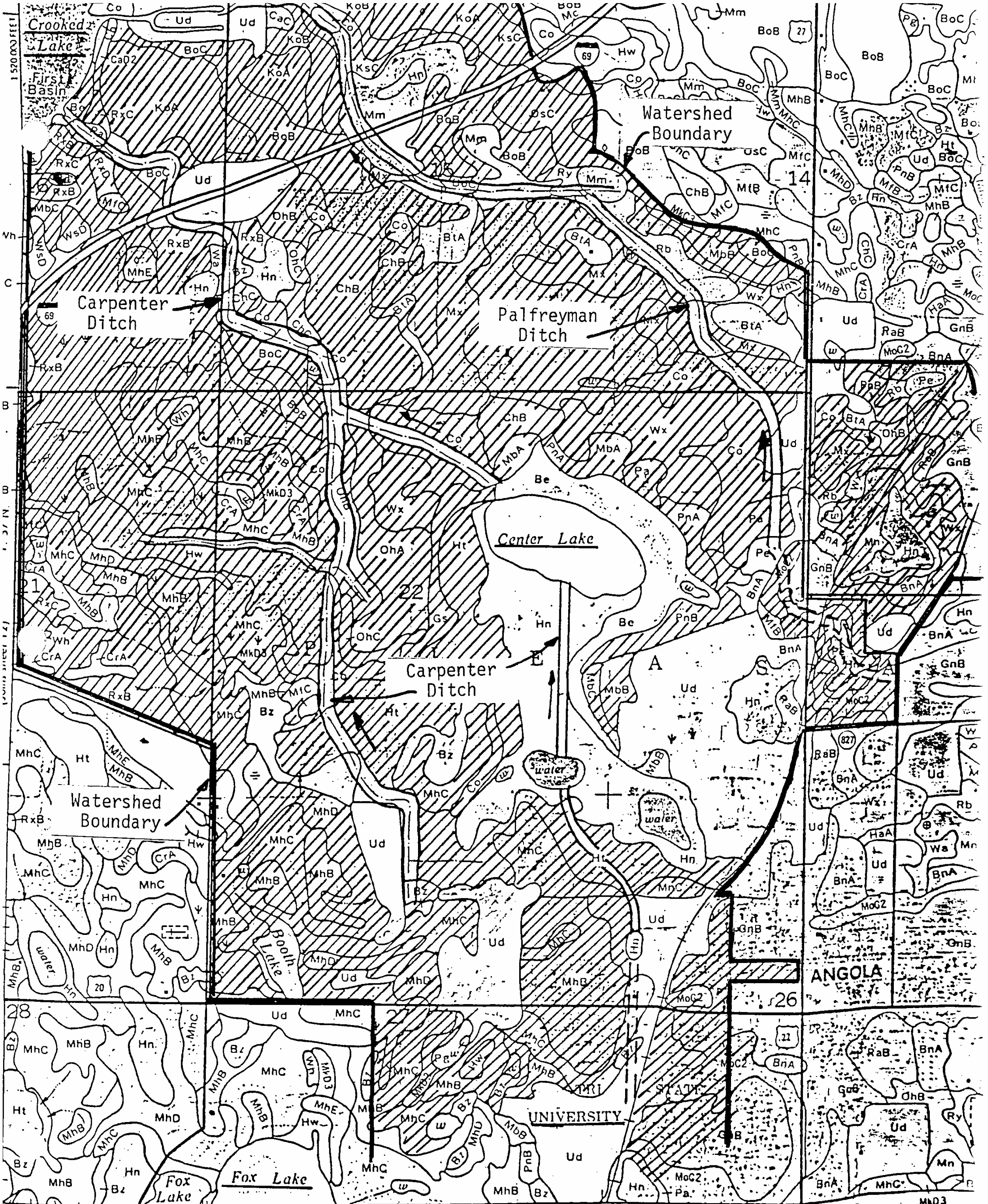


Figure XIII Carpenter and Palfreyman Ditches
Soil Identification

Highly erodible — Ditch course — watershed boundary

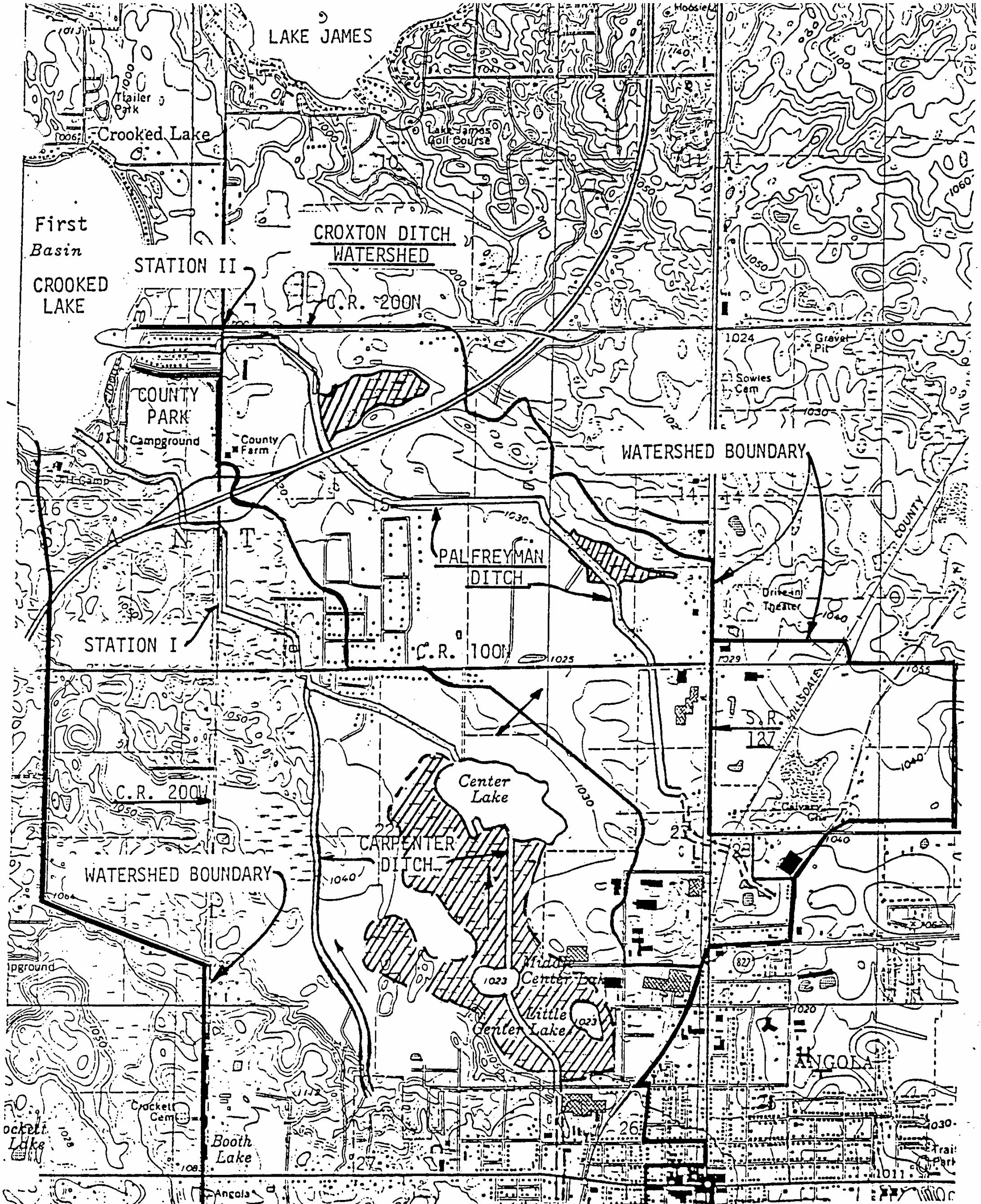


Figure XIV. The Carpenter and Palfreyman Ditches; ~~Land Use~~

Wetland Areas — Ditch Course — Watershed Boundary

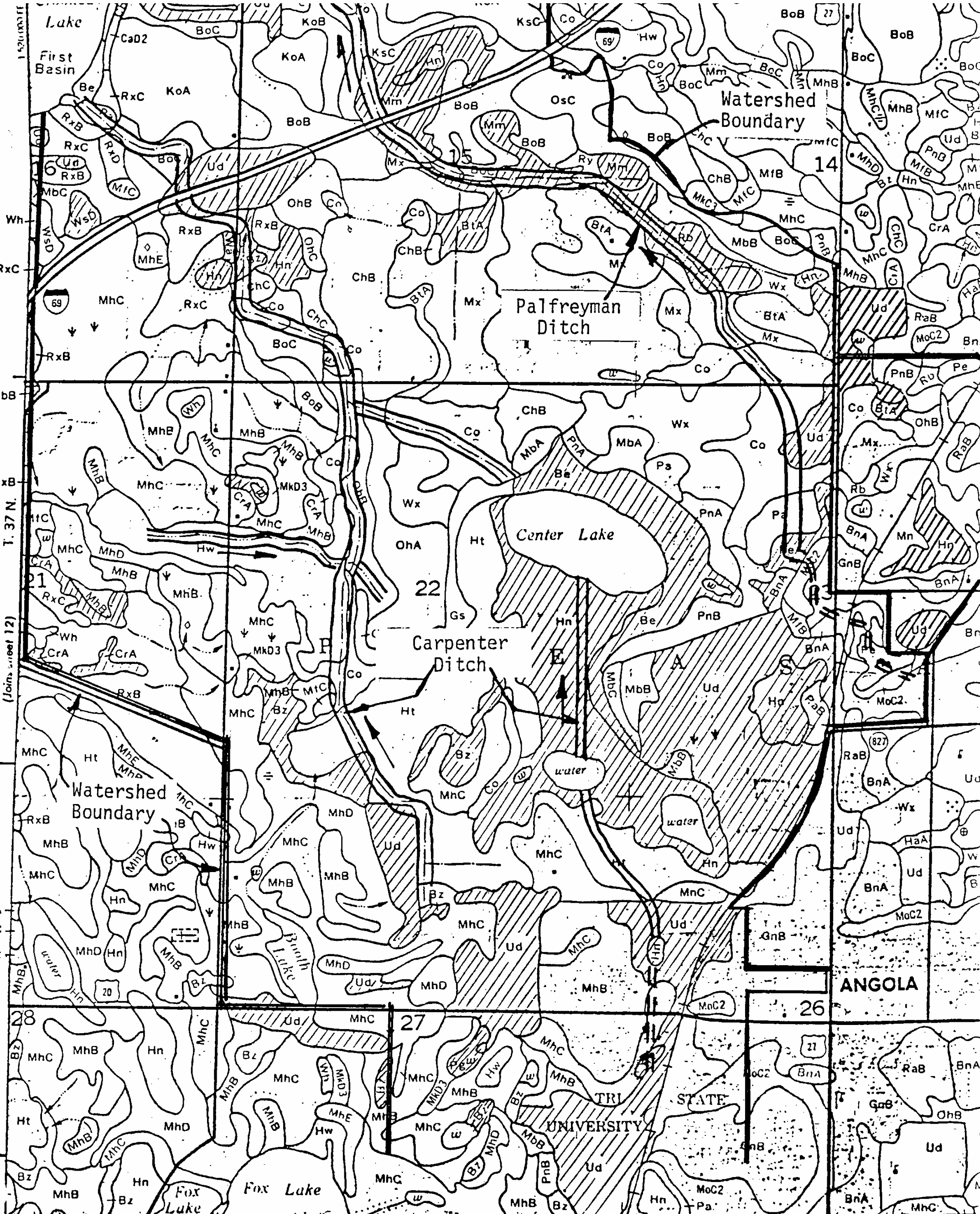


Figure XV Carpenter and Palfreyman Ditches; Soil Identification.

Soils not highly erodible   Ditch Course

Figure XVI MEASURED STORM HYDROGRAPH

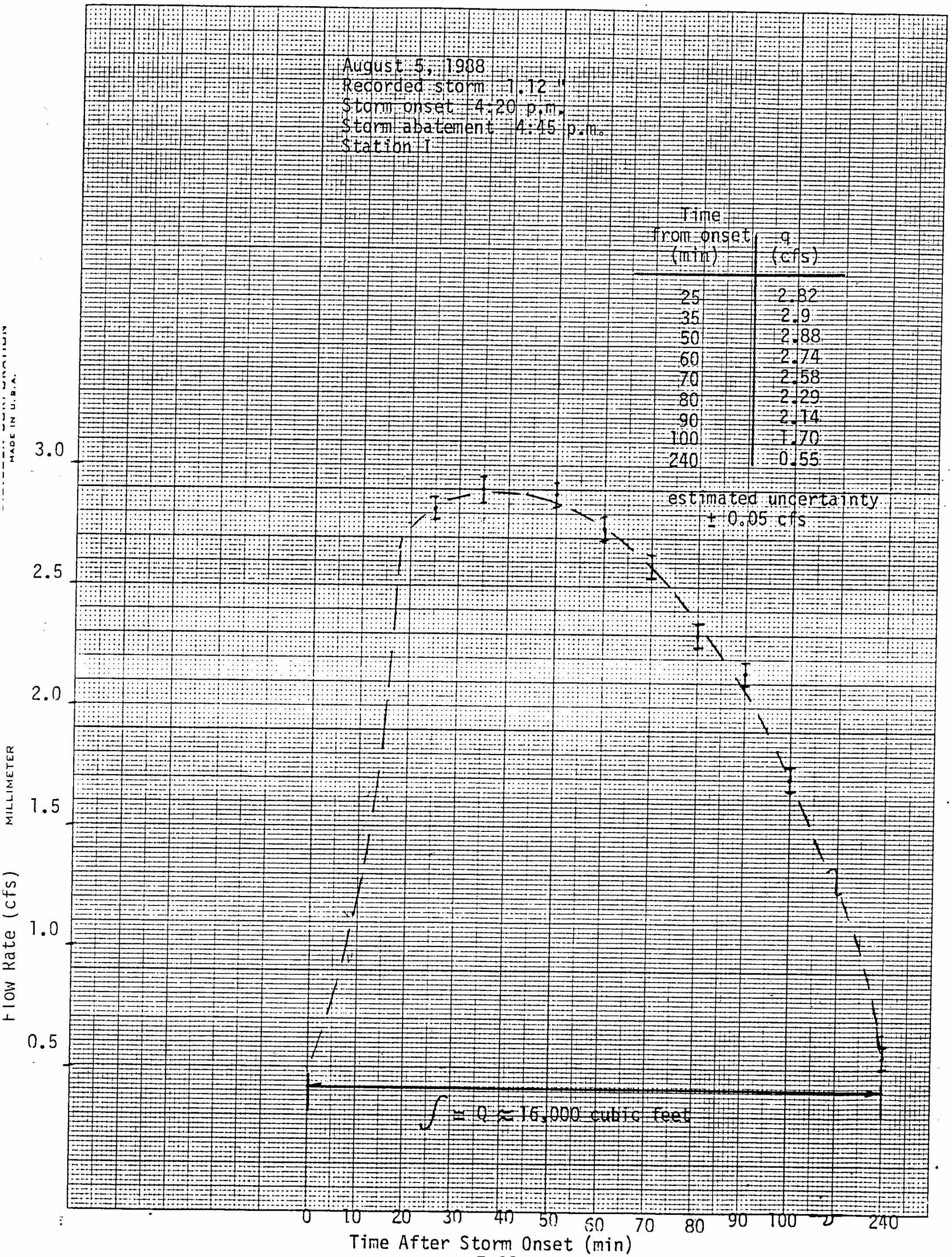
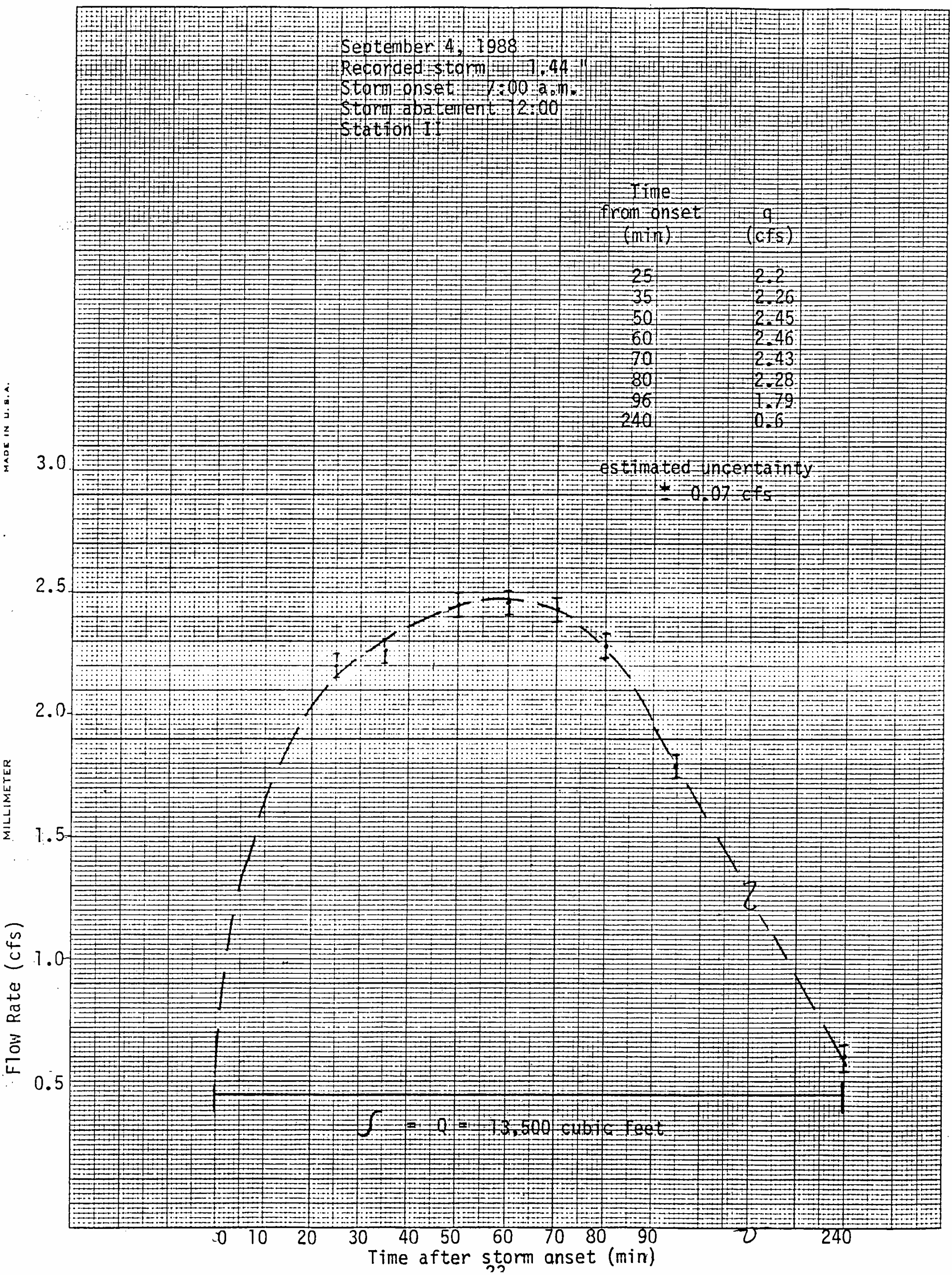


Figure XVII MEASURED STORM HYDROGRAPH



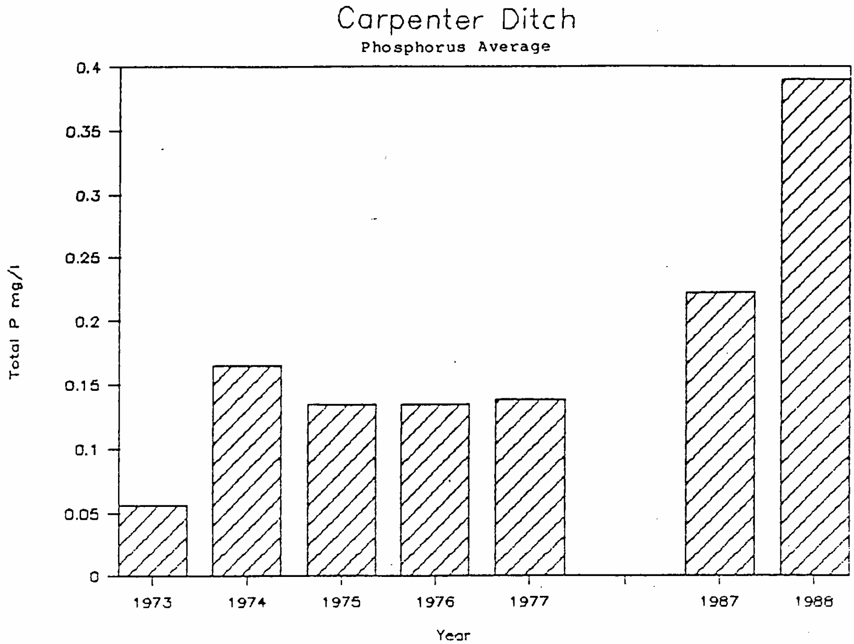


Figure XVIII Carpenter ditch; Total Phosphorus

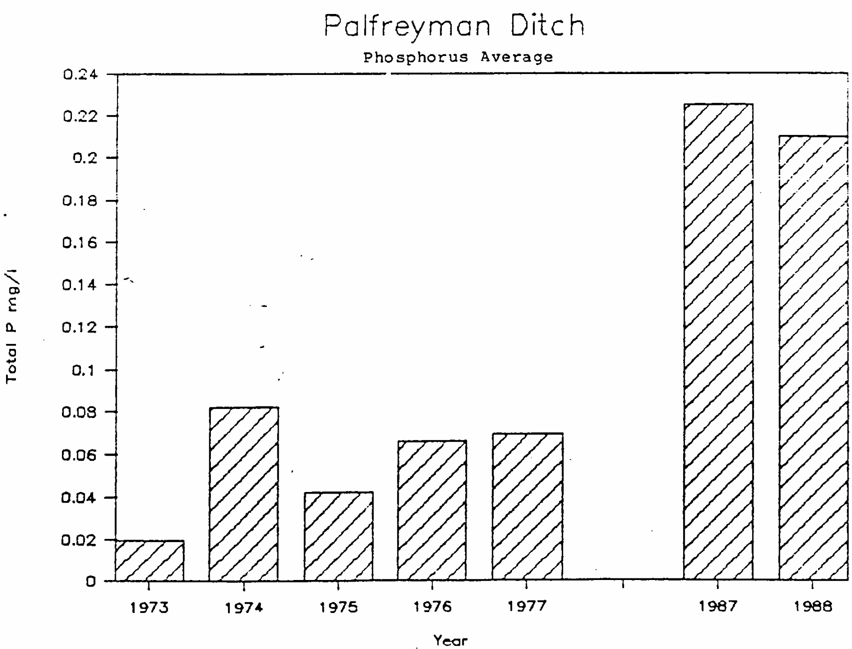


Figure XIX Palfreyman Ditch; Total Phosphorus

Carpenter Ditch			Total Phosphorus mg/l				
1988	5/23	6/16	7/14	7/20	8/5	8/15	8/19
100 N	0.50		0.91			0.19	0.27
Inflow 4-H Park	0.60	0.30	0.15	0.18	0.63	Dry	Dry
Rainfall (inches)	1.98		0.34	0.10	1.12	0.46	0.18

Table 1. Carpenter Ditch - Total Phosphorus Measurements Along Ditch Course

Carpenter Ditch			Suspended Sediments mg/l				
1988	5/23	6/16	7/14	7/20	8/5	8/15	8/19
Inflow 4-H Park	78.00	43.00			32.00	Dry	Dry
Rainfall (inches)	1.98		0.34	0.10	1.12	0.46	0.18

Table 2. Carpenter Ditch, Suspended Sediments at Inflow

Palfreyman Ditch			Total Phosphorus mg/l				
1988	5/23	6/16	7/14	7/20	8/5	8/15	8/19
100 N			0.24		0.36	0.31	0.08
Inflow 200 West	0.60	0.24	0.15	0.33	0.23	0.01	0.12
Rainfall (inches)	1.98		0.34	0.10	1.12	0.46	0.18

Table 3. Palfreyman Ditch, Total Phosphorus Measurements Along Ditch Course

Palfreyman Ditch			Suspended Sediments mg/l				
1988	5/23	6/16	7/14	7/20	8/5	8/15	8/19
Inflow 200 West	96.00	83.00			54.00		
Rainfall (inches)	1.98		0.34	0.10	1.12	0.46	0.18

Table 4 Palfreyman Ditch, Suspended Sediments at Inflow

APPENDIX A

Table I. 1988-89 Rainfall Record, Angola, Indiana

JULY 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES		AMOUNT
July 10	5:30 AM - 7:00 AM		.02
July 10	7:00 AM - 11:30 AM 2:00 PM - 6:30 PM		.90
July 14	5:30 PM - 7:00 AM		.34
July 14	7:00 AM - 7:30 AM		.01
July 16	10:00 PM - 11:30 PM		.22
July 18	2:30 PM - 7:00 PM		.10
July 20	11:30 AM - 1:00 PM		.17
July 23	3:00 PM - 9:00 PM		.67
July 25	5:00 PM - 7:00 PM		.08
July 30	Times Unknown		.15
		TOTAL	2.66

Trace = less than .01 inch of precipitation

NATIONAL WEATHER SERVICE
COOPERATIVE WEATHER STATION
ANGOLA, INDIANA
STATION INDEX 12-0200-03

Edward J. Nagle

EDWARD J. NAGLE
COOPERATIVE OBSERVER

AUGUST 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX 12-0200-03

DATE	TIMES	AMOUNT
Aug 5	4:00 PM - 6:00 PM	1.12
Aug 9		Trace
Aug 10	3:00 PM - 5:00 PM	.09
Aug 15	1:00 AM - 3:00 AM	.23
Aug 15	7:30 AM - 9:00 AM	.46
Aug 18	9:00 PM - 11:00 PM	.50
Aug 19	1:00 PM - 2:00 PM	.18
Aug 23	5:30 AM - 7:00 AM	.63
Aug 23	7:00 AM - 9:00 AM	.02
Aug 27	5:30 PM - 10:00 PM	.63
	TOTAL	3.86

Trace = less than .01 inch of precipitation

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SEPTEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Sept 1	6:00 PM - 12:00 MID	.97
Sept 3	7:00 AM - 12:00 MID	
Sept 4	12:00 MID - 7:00 AM	1.44
Sept 4	7:00 AM - 12:00 NOON	.40
Sept 5	Times Unknown	.07
Sept 12	Times Unknown	.11
Sept 18	3:00 PM - 5:00 PM	.64
Sept 19	8:00 AM - 12:00 MID	
Sept 20	12:00 MID - 6:30 AM	1.32
Sept 20		Trace
Sept 22	Times Unknown	.11
	TOTAL	5.06

Trace = less than .01 inch of precipitation

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OCTOBER 1988 PRECIPITATION
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Oct 2	3:00 AM - 7:00 AM	.54
Oct 2	7:00 AM - 12:00 MID	
Oct 3	12:00 MID - 3:00 AM	.22
Oct 5	Times Unknown	.07
Oct 9	6:00 AM - 7:00 AM	.05
Oct 9	7:00 AM - 9:30 AM	.16
Oct 10	Times Unknown	.07
Oct 11	Times Unknown	.04
Oct 12		Trace
Oct 15	Times Unknown	.32
Oct 16	3:00 PM - 12:00 MID	3.19
Oct 17	Times Unknown	.02
Oct 18		Trace
Oct 19	Times Unknown	.06
Oct 20	Times Unknown	.14
Oct 23	10:00 AM - 2:00 PM	.39
Oct 24	Times Unknown	.03
Oct 26		Trace
	TOTAL	5.30

Trace = less than .01 inch of precipitation

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NOVEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Nov 1		Trace
Nov 3		Trace
Nov 4	11:00 AM - 12:00 MID	.67
Nov 5	7:00 AM - 12:00 MID	
Nov 6	12:00 MID - 7:00 AM	.21
Nov 6	7:00 AM - 11:30 AM	.30
Nov 9		Trace
Nov 10	5:00 PM - 12:00 MID	
Nov 11	12:00 MID - 3:00 AM	.10
Nov 13	12:00 MID - 4:00 AM	.33
Nov 15	6:00 PM - 12:00 MID	
Nov 16	12:00 MID - 7:00 AM	.68
Nov 16	7:00 AM - 12:00 NOON	.82
Nov 20	4:00 AM - 7:00 AM	.28
Nov 20	7:00 AM - 2:00 PM	.68
Nov 26	12:00 NOON- 12:00 MID	
Nov 27	12:00 MID - 7:00 AM	.56
Nov 27		Trace
Nov 29	Times Unknown	.03
	TOTAL	4.66

Trace = less than .01 inch of precipitation

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DECEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Dec. 1	Time Unknown	.05
Dec. 10		T
Dec. 11	Time Unknown	.03
Dec. 13	2:00 AM - 3:00 AM	.07
Dec. 14		T
Dec. 15		T
Dec. 16		T
Dec. 17	Time Unknown	.05
Dec. 18	3:00 AM - Midnight	.07
Dec. 19	Midnight - 4:00 AM	.02
Dec. 20		T
Dec. 22	9:00 AM - 1:00 PM	.92
Dec. 25	Time Unknown	.15
Dec. 26 Dec. 27	7:00 AM - Midnight Midnight - 7:00 AM	.68
Dec. 28	7:00 AM - 9:00 AM	.48
	TOTAL	2.52

Trace = less than .01 inch of precipitation

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JANUARY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Jan. 2		T
Jan. 3	9:00 AM - 12:00 N	.10
Jan. 5 Jan. 6	9:00 PM - Midnight Midnight - 7:00 AM	.55
Jan. 7	7:30 PM - 11:00 PM	.48
Jan. 11	Time Unknown	.07
Jan. 14	3:00 PM - 6:30 PM	.18
Jan. 20	Time Unknown	.04
Jan. 25 Jan. 26	8:00 PM - Midnight Midnight - 3:00 AM	.16
Jan. 29	1:30 AM - 3:00 AM	.14
Jan. 30	Time Unknown	.06
	TOTAL	1.68

Trace = less than .01 inch of precipitation

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FEBRUARY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Feb. 2	Time Unknown	.03
Feb. 3		T
Feb. 5	Time Unknown	.12
Feb. 6	Time Unknown	.24
Feb. 12		T
Feb. 13	10:30 AM - 12:30 PM	.19
Feb. 16	Time Unknown	.05
Feb. 19	Time Unknown	.02
Feb. 20	Time Unknown	.02
Feb. 21		T
Feb. 22		T
Feb. 23		T
Feb. 27		T
Feb. 28		T
	TOTAL	1.05

Trace = less than .01 inch of precipitation

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MARCH 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Mar. 3	Time Unknown	.02
Mar. 4	3:00 AM - 7:00 AM	.22
Mar. 5	Time Unknown	.03
Mar. 14	8:00 PM - 9:00 PM	.09
Mar. 15	Time Unknown	.02
Mar. 17 Mar. 18	6:00 PM - Midnight Midnight - 1:30 AM	.78
Mar. 19		T
Mar. 20	11:00 AM - 12:30 PM	.16
Mar. 27	12:00 N - 1:30 PM	.03
Mar. 28	9:00 PM - 10:30 PM	.17
Mar. 30	Time Unknown	.04
Mar. 31		T
	TOTAL	1.57

Trace = less than .01 inch of precipitation

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APRIL 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Apr. 1		T
Apr. 2	9:00 AM - 8:00 PM	1.08
Apr. 3	Time Unknown	.43
Apr. 4	Time Unknown	.10
Apr. 7	Time Unknown	.07
Apr. 8		T
Apr. 9		T
Apr. 10		T
Apr. 11		T
Apr. 12		T
Apr. 13	Time Unknown	.15
Apr. 15	Time Unknown	.09
Apr. 18	Time Unknown	.26
Apr. 19	Time Unknown	.19
Apr. 25	5:30 AM - 8:00 AM	.41
Apr. 28	5:00 AM - 11:00 AM	.65
	TOTAL	3.43

Trace = less than .01 inch of precipitation

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MAY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
May 2	7:30 AM - 9:00 AM	.19
May 5	Time Unknown	.09
May 6		T
May 7	Time Unknown	.02
May 9	6:00 AM - 9:00 AM	.13
May 12 May 13	9:00 PM - Midnight Midnight - 3:00 AM	.44
May 14	Time Unknown	.04
May 16	Time Unknown	.03
May 19	5:00 AM - 6:00 PM	1.10
May 25	4:00 AM - 6:00 AM	.85
May 26	7:30 PM - 11:30 PM	.43
May 29		T
May 30	1:00 PM - 2:30 PM 8:30 PM - 11:30 PM	2.63
	TOTAL	5.95

Trace = less than .01 inch of precipitation

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JUNE 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
June 1	9:30 AM - 2:00 PM	1.29
June 3	11:00 AM - 5:00 PM	.61
June 11	10:00 AM - 6:00 PM	.47
June 14	Time Unknown	.07
June 15		T
June 16	Time Unknown	.04
June 17	3:00 PM - 4:00 PM	.12
June 19	3:00 PM - 5:00 PM	1.66
June 27	11:00 AM - 12:30 PM	.15
	TOTAL	4.41

Trace = less than .01 inch of precipitation

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JULY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
July 2	3:30 PM - 4:30 PM	.12
July 9	3:30 AM - 7:00 AM	.59
July 11	3:00 AM - 6:00 AM	1.75
July 13	11:00 AM - 12:30 PM	.08
July 19	5:00 AM - 8:00 AM	.19
July 20		T
July 21	4:30 AM - 9:30 AM	.30
July 25	9:30 PM - 11:30 PM	1.02
July 27	Time Unknown	.02
July 28	Time Unknown	.06
July 30	4:00 AM - 8:00 AM	.37
	TOTAL	4.50

Trace = less than .01 inch of precipitation

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